An Introduction to the NuMI Project and the Minos Experiment

Robert Plunkett/Fermilab
NuMI Deputy Project Manager

Fermilab All Experimenters Meeting
6 October, 2003

Why this introduction?

- Who we are
  - Project, Collaboration and Laboratory
- What we are doing
  - Construction activities and timetable
  - Soudan operations
- How we'll be telling you about it.
  - Preliminary schedule of presentations to this meeting.

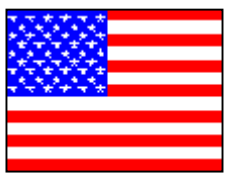
The NuMI Project

- Build and commission a major beamline, including tunnels and surface buildings, and all beamline components, for long-baseline neutrino physics
- A new cavern and lab facilities at Soudan, Minnesota
- Two major detectors
- $170 M of net value
- Involvement and excellent support from all Fermilab Divisions and Sections

The MINOS Collaboration

Athens • Cambridge • College de France • ITEP-Moscow • Oxford • Protvino • Rutherford • Sussex • UCL • Argonne • Brookhaven • Caltech • Fermilab • Harvard • IIT • Indiana • Lebedev • Livermore • Macalester • Minnesota • Minnesota-Duluth • Pittsburgh • South Carolina • Stanford • Texas-Austin • Texas A&M • Tufts • Sao Paolo • Western Washington • UNICAMP/Campinas • Wisconsin

27 Universities, 4 National Laboratories, 6 Countries
More than 150 collaborators





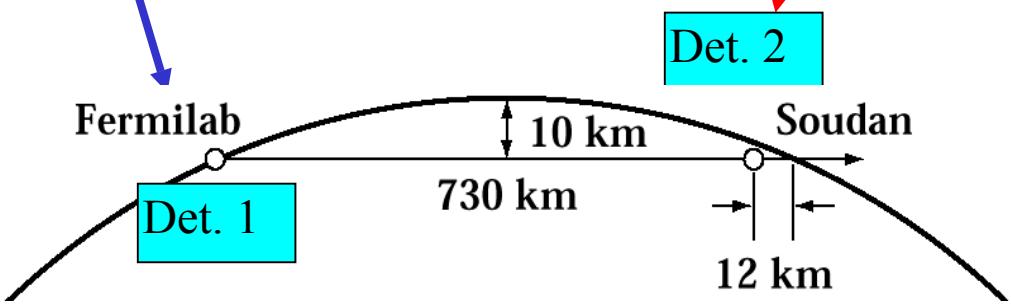

MINOS Long-Baseline Experiment

Fermilab to Soudan, Minnesota

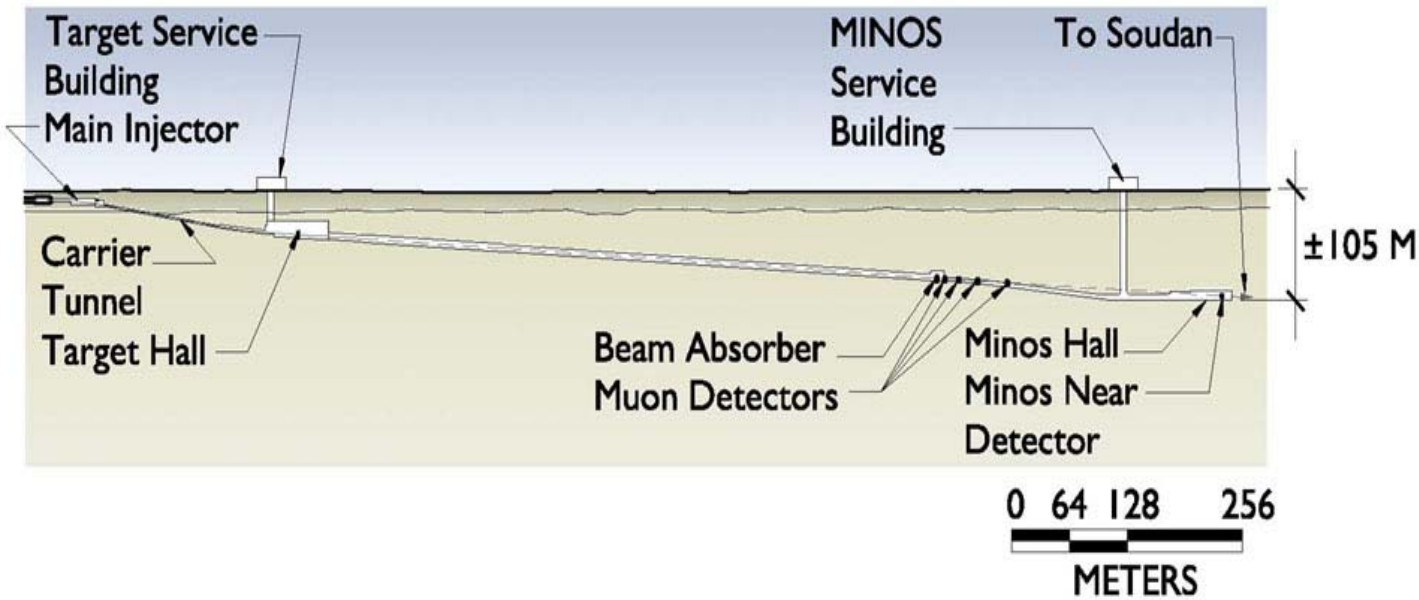
Beam in 2003

Far Detector: 5400 tons

Near Detector: 980 tons



Schematic of NuMI Complex (Fermilab Part)



- **Major complicated conventional construction**
- **Three *major* installations in three *different* areas:**
  - Several hundred feet of accelerator enclosure—half of which is between two operating machines
  - Downstream end of carrier tunnel, Pre-Target and Target Areas--primary beam focus, entrance to decay tunnel
  - MINOS area—beam monitoring, ~1 KT hadron absorber and ~ 1 KT neutrino

Civil Construction of Two Buildings

MI65, gateway to the Target Hall, will be finished first.

Minos Service Building houses a 300 ft. shaft leading to the detector.

Completed NuMI Decay Tunnel

6m diameter excavated via Tunnel Boring Machine

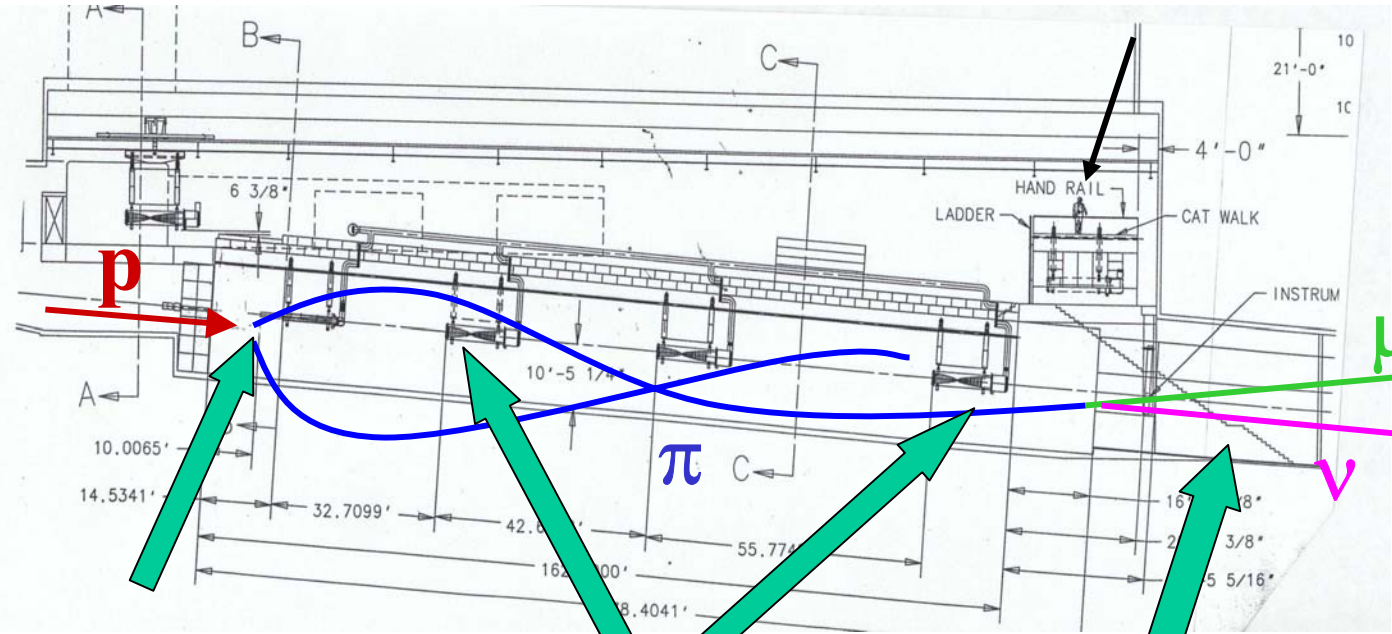
Descends at 3.3 degrees – 6%

Now filled with decay pipe, shielding, and access passageway.

Beamline and Focusing Layout

vertical scale exaggerated!

Physicist



120 GeV primary Main Injector beam

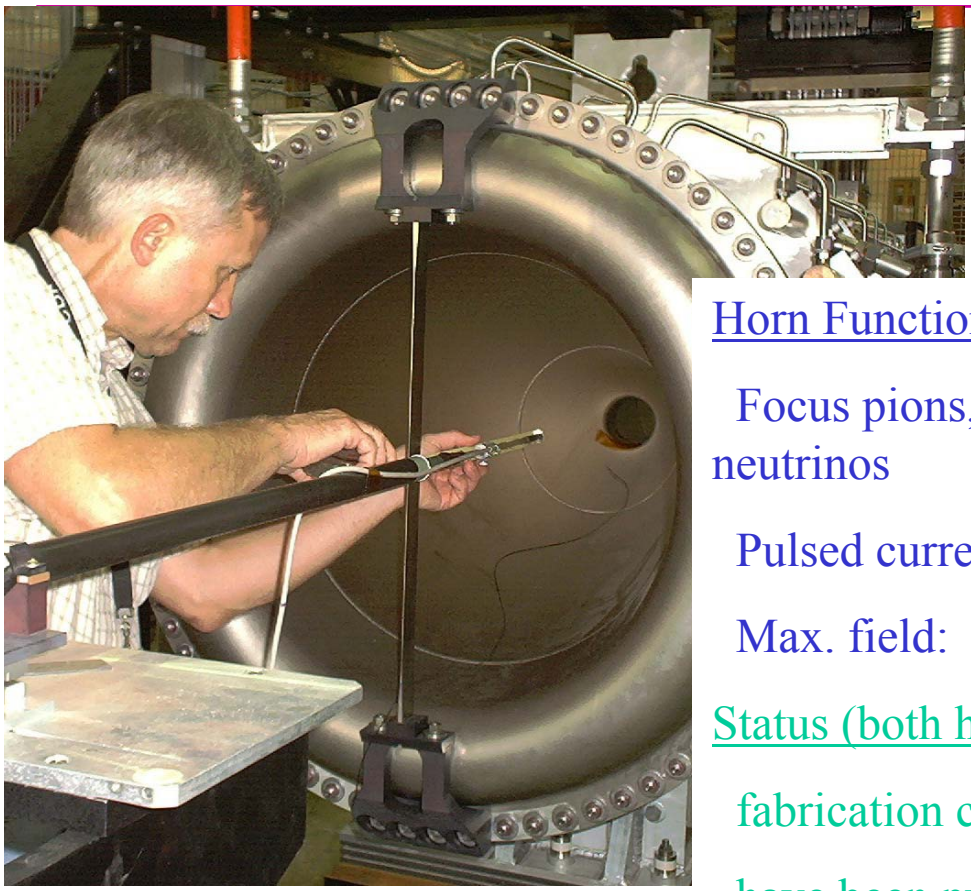
2-horn beam adjusts for variable energy ranges

675 meter decay pipe for π decay
240 meter rock muon absorber

NuMI Target Hall

High and narrow to allow installation of target and horn systems and shielding.

Status of Horns



Horn Function:

Focus pions, which decay to neutrinos

Pulsed current: 205,000 Amps

Max. field: 3 Tesla

Status (both horns): *ready!*

fabrication complete

have been pulsed > 400k times eac

magnetic field quality checked

vibration checked

Next steps:

Test fit onto support/alignment modules

Practice remote (hot) handling

Install in target hall May 2004

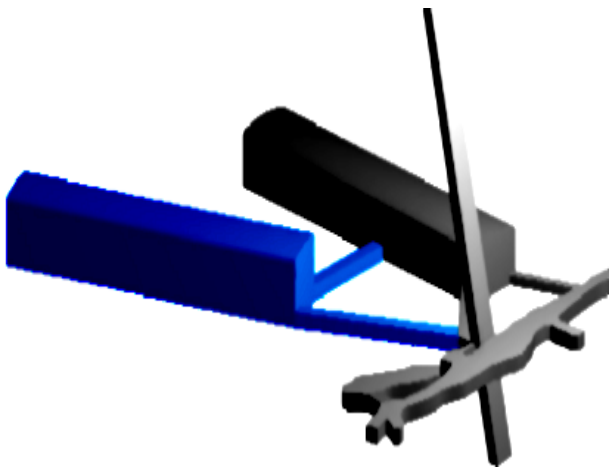
Magnet Installation in MI and "Stub" Underway

"Porch" Area, heading underground

Stub area, heading toward porch

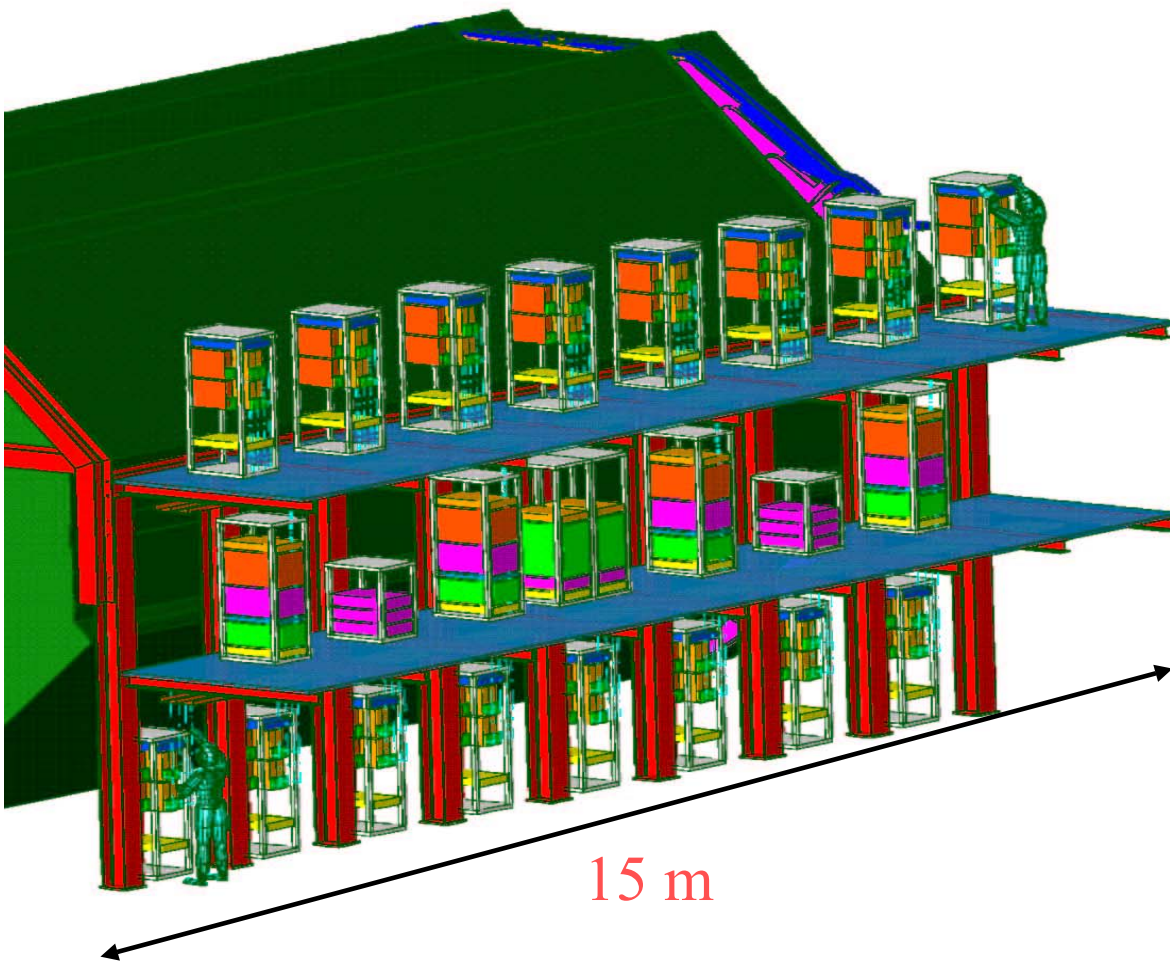
Soudan Underground Laboratory

- Operated by U. of Minn. and Minnesota Dept. of Natural Resources
- Soudan Mine -tourist attraction during summer months
- 1 elevator shaft limits loads to 1m x 2m x 9m

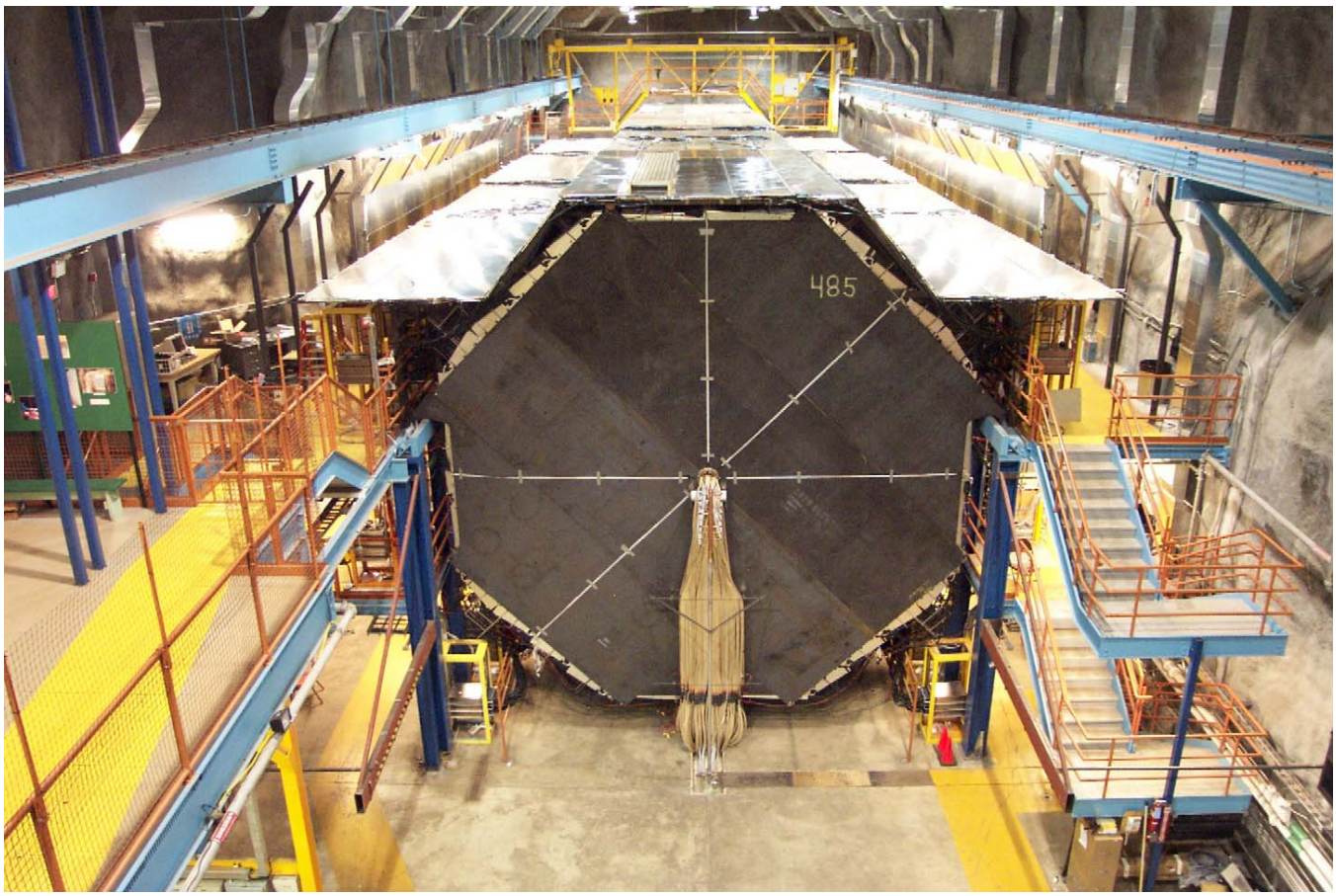


Zoom View of MINOS Supermodule

- 8m Octagonal Tracking Calorimeter
- 486 layers of 2.54cm Fe
- 2 sections, each 15m long
- 4.1cm wide solid scintillator strips with WLS fiber readout
- Magnet coil provides <B> ≈ 1.3T
- 5.4kt total mass



Completed Minos Far Detector

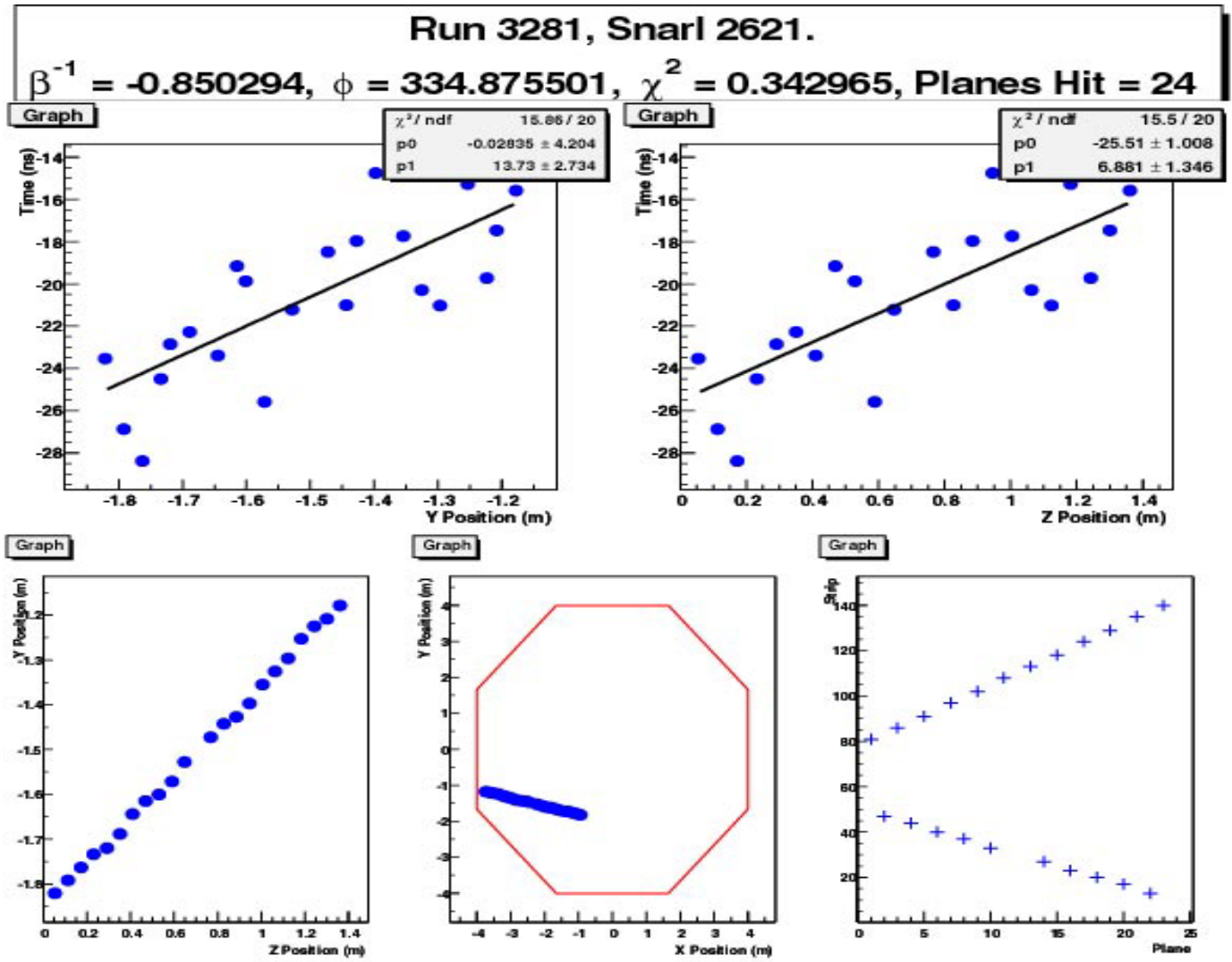


Two supermodules finished, energized Summer ’03

Operating on cosmic rays and atmospheric neutrinos
(Magnetic field allows event-by-event separation of antineutrinos)

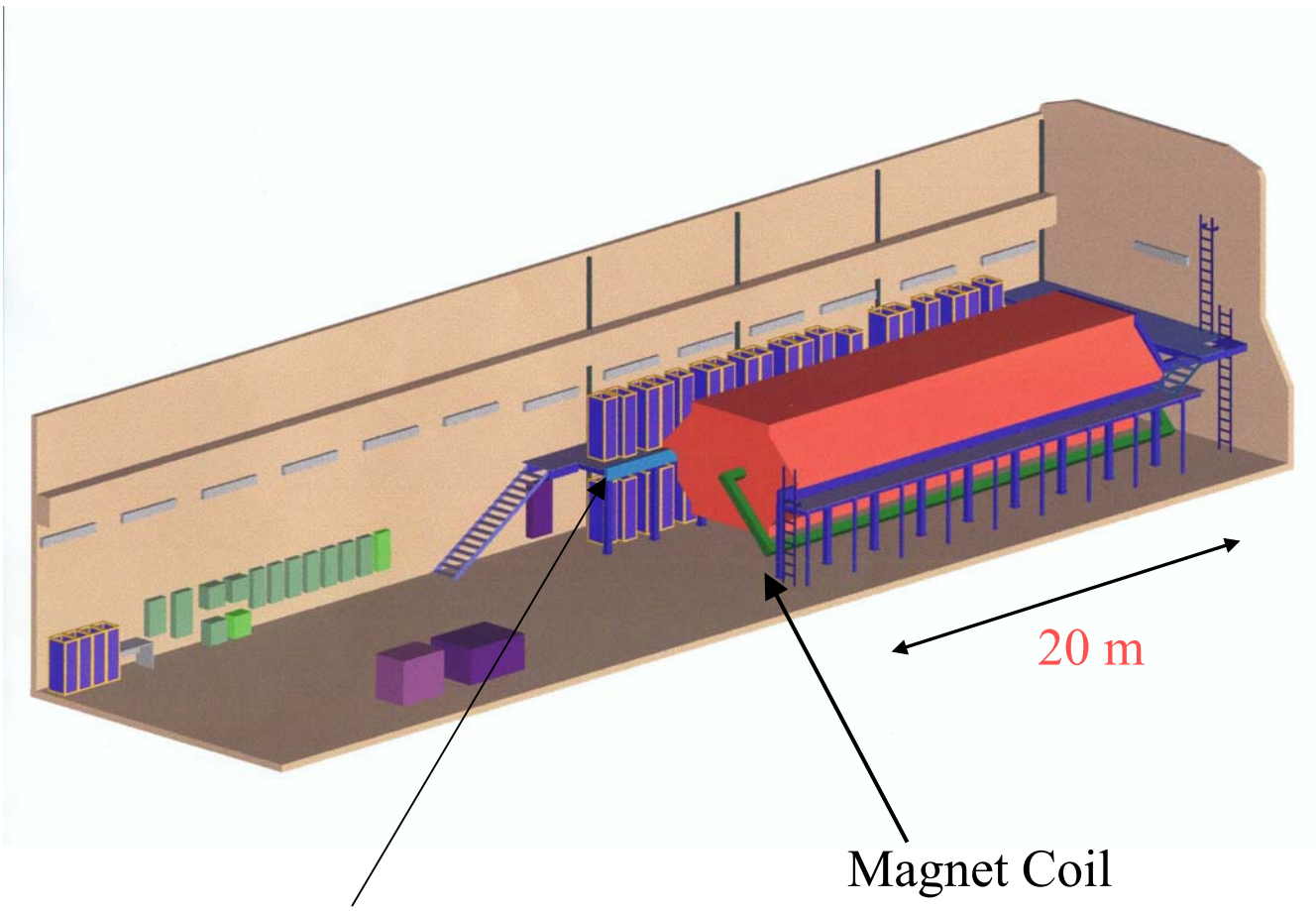
Currently commissioning remote operations model

First Minos Neutrino Event (2002)



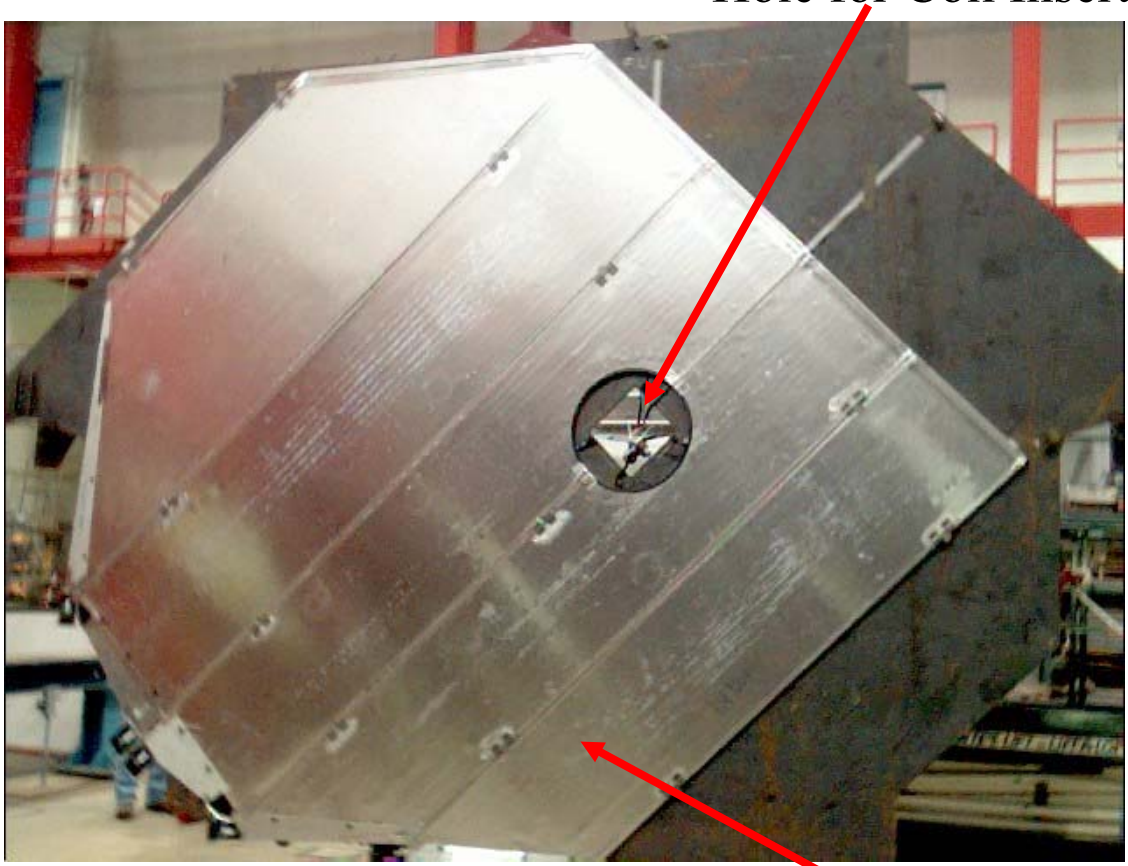
- Upgoing muon passing through about 3.5 m of the detector. ($p_\mu > 1.9$ GeV/c)
- Magnetic field was not on at this time so no measurement of the momentum.

Layout View of MINOS Near Detector



90 m below ground
Cavern 46 m in length, ~ 10 m high
Access via ~ 6.5 m diameter shaft

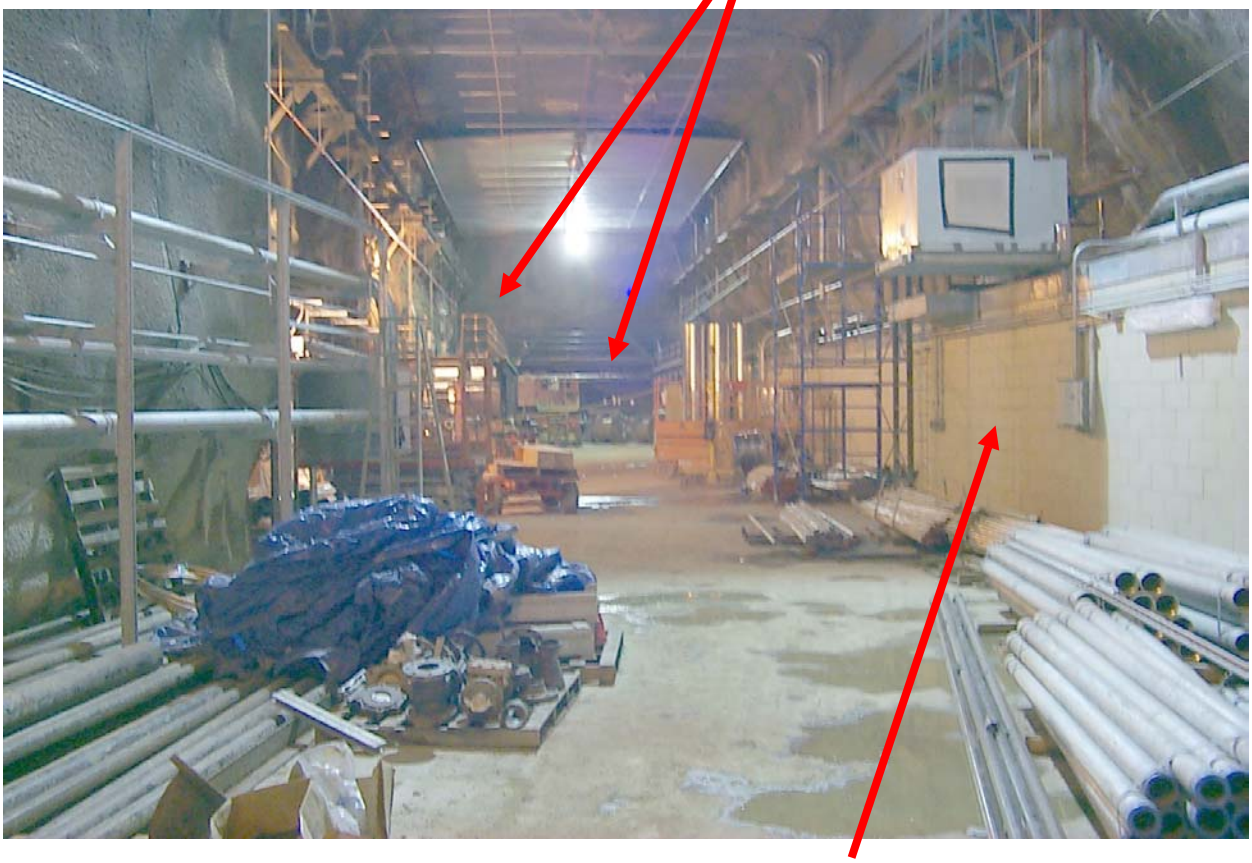
Near Detector Plane Assembly Complete



Stored on racks in New Muon Lab
Installation equipment tested
Magnet coils delivered, ready
PMT systems (UK) delivered, ready

Minos Hall Outfitting

Detector Supports



Egress Passageway

Detector's Eye View as it will be installed beginning spring 2004

Status of NuMI Project

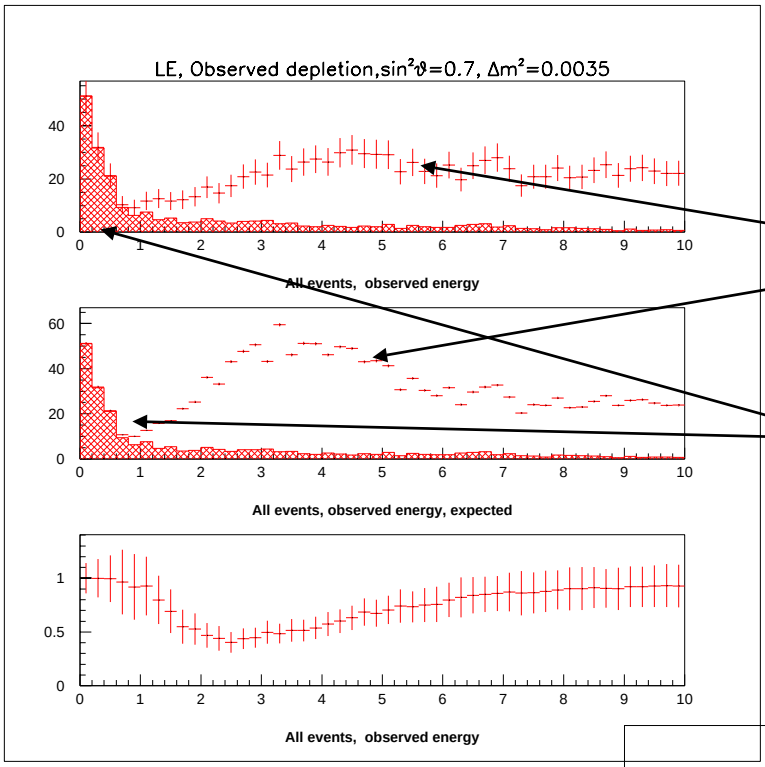
- MINOS far detector complete.
  - Reading out with magnet.
- MINOS near detector main construction complete.
  - Electronics in use at CERN testbeams.
  - Auxiliary systems being assembled.
- Buildings and Outfitting at Fermilab nearing end.
  - Finished by 1/31/04, 10/20/03 for MI65 section.
- Beamline installation ongoing.
- Expect to begin commisioning at end of 2004.

Schedule of Future Presentations

- Beamline Installation in 2003 – status.
- Far Detector Running in Soudan
- Minos Near Detector status
- Characteristics of NuMI Neutrino Beam
- Beamline installation plans for 2004
- Collaboration on accelerator projects.

Sequence preliminary
Interval about every 2 weeks

Beam and Oscillation Signal



Low Energy

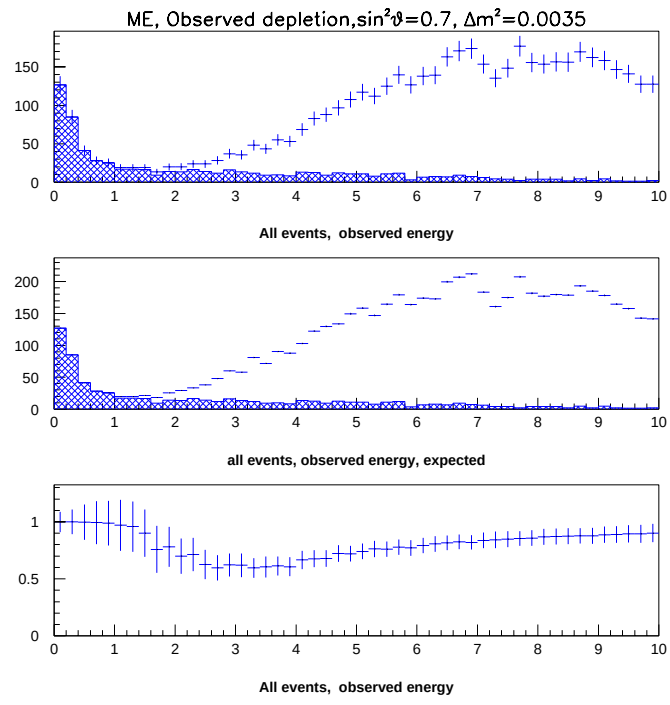
Visible Energy, all identified CC

Residual NC background

Medium Energy

Goals of choice of beam operating conditions

* Maximize signal
* Minimize systematics
* Optimize coverage for "appropriate" parameters

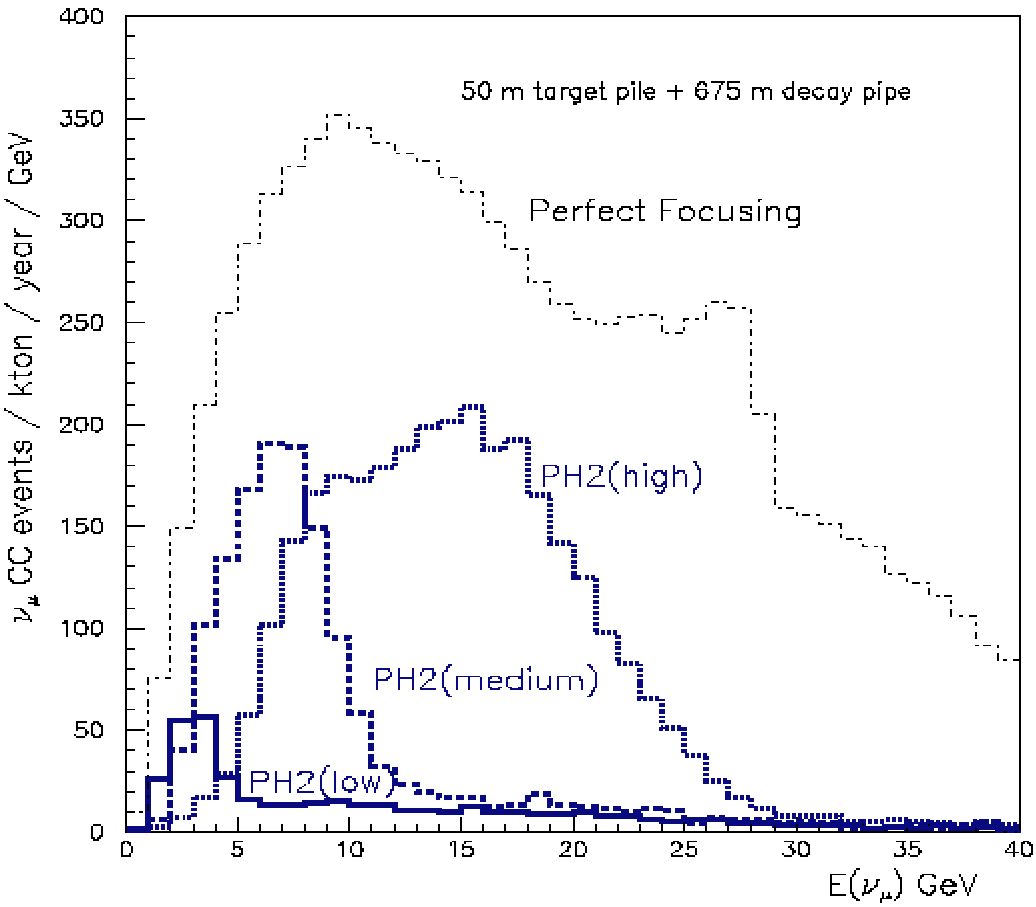


Underground Construction,cont.

Decay pipe section coming underground

Interior of decay pipe

Beam Energy Options

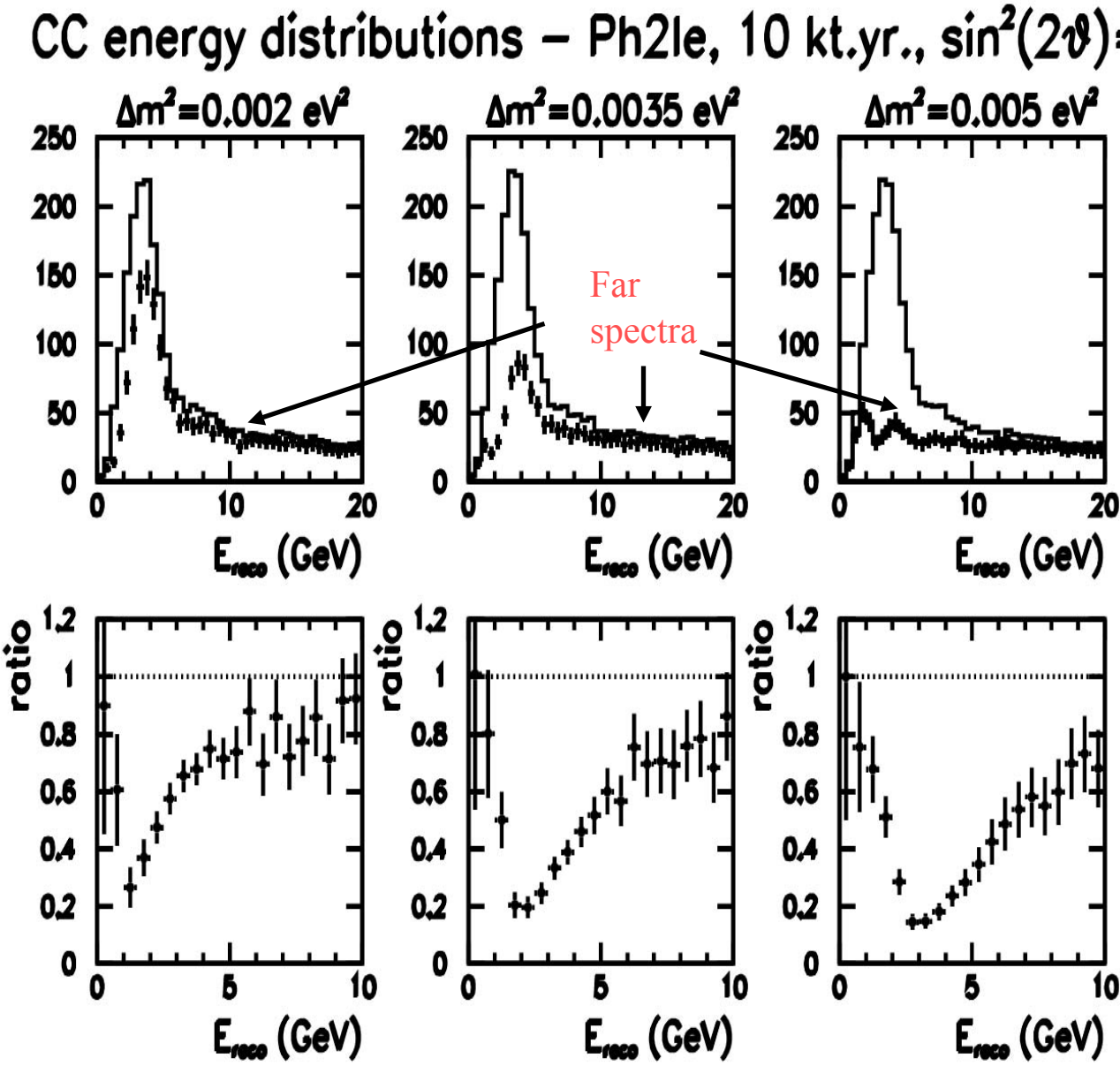


Example spectra from varying horn positions

CC Events in MINOS 5kt detector

High	~ 15,000/yr	(< 30 GeV)
Medium	~ 6200/yr	(< 20 GeV)
Low	~ 1500/yr	(< 15 GeV)

Oscillation Signals



High-statistics ratio of far/near spectra will provide dramatic evidence for oscillation, and effective tool for studying the effect

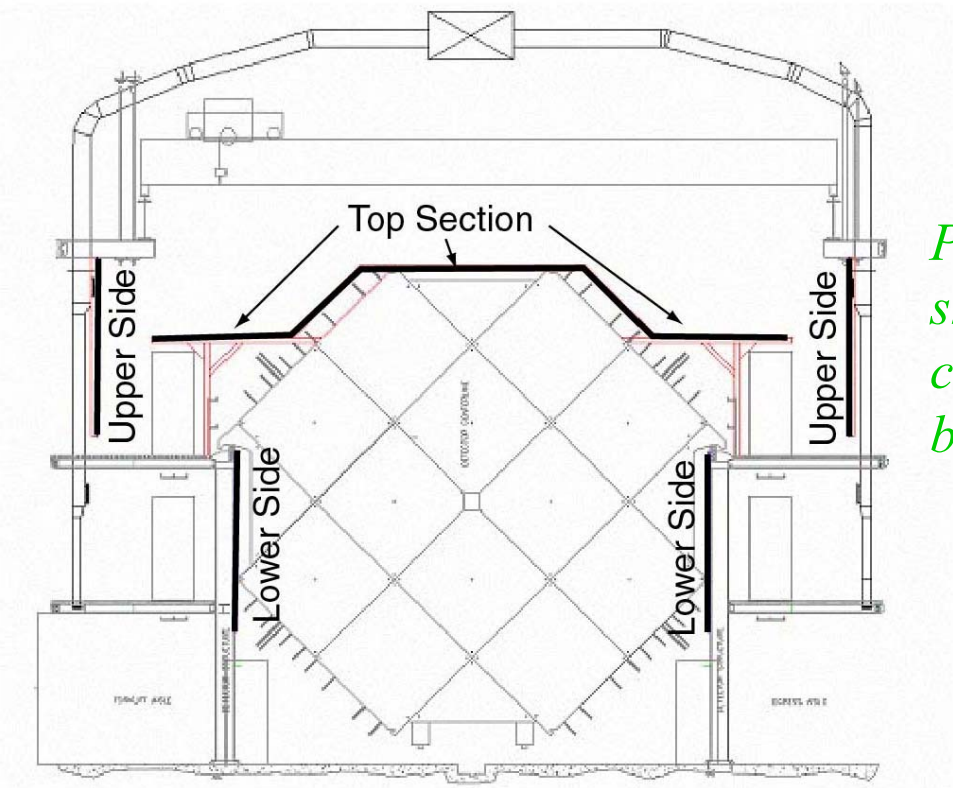
MINOS as Atmospheric Neutrino Detector

MINOS is first large underground detector with a magnetic field.

Will directly compare ν_μ and anti-ν_μ oscillations in atmospheric region.

More than 1000 total events expected in 24 kT-years

Competitive limits on CPT violation will be obtained.



Proposed veto shield to reduce cosmic ray backgrounds

Physics Goals of the Minos Experiment

Demonstrate oscillation behavior.

Using the CC rate and spectrum

(2-4% sys. Uncertainty per 2 GeV bin)
Look for "standard" oscillatory spectrum.

Using the NC/CC ratio.

Precisely Measure the oscillation parameters

δm^2 and $\sin^2 2\theta$

CC energy distribution the principal tool here.

Gain information about the oscillation modes.

NC/CC to check for ν_τ vs. $\nu_{sterile}$

Identification of ν_e

Near Detector reduces uncertainties, provides normalization of rates.

Spectrometer provides powerful analysis tool